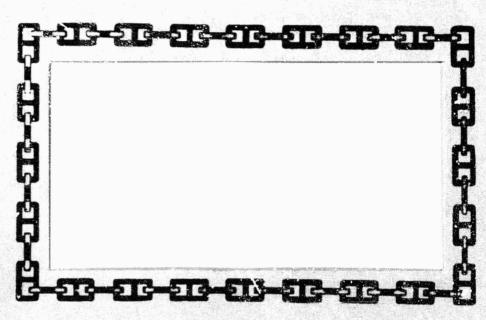




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# U. S. NAVY EXPERIMENTAL DIVING UNIT





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## NAVY EXPERIMENTAL DIVING UNIT WASHINGTON NAVY YARD WASHINGTON, D.C. 20390

## RESEARCH REPORT 9-70

SATURATION DIVES, WITH EXCURSIONS, FOR THE DEVELOPMENT OF A DECOMPRESSION SCHEDULE FOR USE DURING SEALAB III

23 September 1970

Written by

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#### ABSTRACT

Twenty-three saturation dives to depths of 200 to 850 feet were conducted at the US Navy Experimental Diving Unit to verify a decompression schedule for use at SEALAB III. Seventy-one divers completed ninety-seven man-dives and tested decompression schedules based on two different fundamental rates of ascent during the dive series. Seventy-four man-excursion dives were conducted during the series, including a record-breaking excursion to a depth of 1025 feet. A decompression schedule for use from a depth of 600 feet was developed and found to be safe for use during SEALAB III.

Eight cases of decompression illness occurred during the dive series. Details of these cases are covered in this report.

## SUMMARY

## Problem:

1. To verify a decompression schedule for use at SEALAB III.

## Method:

1. Twenty-three dives were conducted at the Navy Experimental Diving Unit. Seventy-one divers were utilized on ninety-seven man-dives from base depths of 200 to 850 feet. Excursions to deeper depths were made on thirteen of the dives, including a record-breaking excursion give to 1025 feet. Decompression schedules based on two different fundamental rates of ascent were tested during this sequence.

## Findings:

1. A decompression table from the depth of 600 feet was developed and found to be effective and safe for use during SEALAB III.

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#### 1. INTRODUCTION

## 1.1 Background

- 1.1.1 The concept of a pressurized work compartment to enable divers to work for extended periods of time underwater is not new. As early as 1907, in a report of studies on diving to the Admiralty submitted by J. S. Haldane, a proposal for a submersible decompression chamber was submitted by the renowned British physiologist, Dr. Leonard Hill (1,2). This chamber was eventually designed and manufactured by Sir Robert Davis of Seibe Gorman, Ltd., and after thirty years of operation, is still being used by the British Navy.
- 1.1.2 As the need for extended underwater work periods became more evident, a project with the code name GENESIS was conducted to determine the effect of saturation diving on man. This first series of studies began in 1957 at the Naval Medical Research Laboratory (NMRL) in New London, Connecticut, under the direction of CDR George F. Bond, MC, USN; CDR Walter F. Mazzone, MSC, USNR; and CDR R.D. Workman, MC, USN.
- 1.1.3 The first two of the five phases of Project GENESIS were conducted on animals under laboratory conditions, in a dry pressure-chamber environment, breathing different types of gases. The Phase A and B experiments were performed to depths of 200 feet and for a period of up to two weeks to demonstrate the feasibility of saturation diving. Larsen and Mazzone (3) effectively describe "Saturation Diving" as diving operations in which divers undergo increased pressure, either in the sea or in a pressure chamber, and remain there for a period of time longer than twenty-four hours. This principle allows all the tissues of the body to become saturated with the inert gas or gases being breathed. As Workman so clearly illustrates (4), with the use of saturation diving, divers may continue to work productively on the job without additional decompression being required following the first twenty-four hours of exposure to pressure. With the completion of Phase B of Project GENESIS, interest in hyperbaric research began to wane. Soon, however, due to the Navy's interest in manned space flight, attention was called to the need for research on helium-oxygen environments for space craft. As a result, Project GENESIS became a formal Navy program, and work progressed at flank speed(7).

- 1.1.4 Phases C, D, and E of GENESIS were laboratory pressure tests with human subject, and culminated in an experimental saturation dive by three men to a depth of 200 feet for twelve days in a dry chamber without suffering ill effects (5). This successful dive completed the laboratory phase of the US Navy's Man-In-The-Sea Program, which was followed by the placing of human divers on the actual sea bottom; the SEALAB I and II operations of August 1964 and October 1965, respectively. The calculations for the saturation decompressions on the SEALAB experiments were originally conceived and developed by Workman of the Experimental Diving Unit (EDU) (5,6).
- On 9 February 1966, the Deep Submergence Systems Project -DSSP - (which had beer in existence for almost two years), was re-aligned as a separate Chief of Naval Materiel -designated organization (PM-11), and given the requirement to support a SEALAB III experiment as part of the Man-In-The-Sea Program. The impetus to this task was, in part, derived from the overwhelming success of SEALAB II, which demonstrated that divers could live and work at a depth of 205 feet for fourteen to thirty days without having to experience decompression more than once (at the conclusion of the dive). Plans were then formulated to conduct the SEA-LAB III experiment, in which divers would live in an underwater habitat for extended periods of time at an approximate depth of 400 feet, and perhaps conduct excursion dives to depths greater than their base depth. Consequently, DSSP was tasked with the development of a saturation-excursion dive format and decompression schedule for use during the experiment. As the testing and training program progressed at EDU, the decision was made to go for a deeper depth - 600 feet, which was the approximate depth to which the SEALAB III habitat was lowered in February of 1969.

## 1.2 Objectives

- 1.2.1 To provide a decompression schedule suitable for use during the SEALAB III experiment.
- 1.2.2 To conduct biomedical, diving equipment, and human-performance studies when practical.
- 1.2.3 To provide training in saturation—excursion diving techniques for the SEALAB aquanauts.
- 1.2.4 To obtain an index for the individual's physiological capability as a participant in the SEALAB III experiment.

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Twenty-three saturation dives to depths of 200 to 850 feet were conducted at the US Navy Experimental Diving Unit to verify a decompression schedule for use at SEALAB III. Seventy-one divers completed ninety-seven man-dives and tested decompression schedules based on two different fundamental rates of ascent during the dive series. Seventy-four manexcursion dives were conducted during the series, including a record-breaking excursion to a depth of 1025 feet. A decompression schedule for use from a depth of 600 feet was developed and found to be safe for use during SEALAB III.

Eight cases of decompression illness occurred during the dive series. Details of these cases are covered in this report.

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# 1.3 Scope

1.3.1 Twenty-three saturation dives to depths of 200 to 850 feet were conducted at the US Navy Experimental Diving Unit to verify a decompression schedule for use at SEALAB III. Seventy-one divers completed ninety-seven man/dives and tested decompression schedules based on two different fundamental rates of ascent. Seventy-four man-excursion dives were conducted during the series, including a record-breaking excursion to a depth of 1025 feet.

#### 2. PROCEDURES

## 2.1 Experimental Subjects

- 2.1.1 Seventy-one qualified US Navy, foreign navy, and government civilian divers in good physical condition participated in the twenty-three saturation dives, including twenty-six divers who participated in more than one dive. A total of ninety-seven diver exposures were completed during this series. Their physical characteristics and diving qualifications are listed in Appendix C.
- 2.1.2 Each subject received a complete physical examination immediately before and after his dive, including audiograms and long-bone X-rays.

## 2.2 Dive Procedures

- 2.2.1 The experimental dives described in this report were conducted under controlled conditions in a diving chamber with a wet-pot. The subjects normally lived in the dry portion of the chamber complex, but would enter the wet-pot for wet experiments and excursions to depths deeper than the base saturation depth. Twenty-three dives to saturation depths of 200 to 850 feet were completed.
- 2.2.2 Four subjects participated in each saturation dive, except the last five dives, where five subjects per dive were used.

## 2.3 Chamber Atmosphere Analysis and Control

2.3.1 Oxygen analysis was accomplished using the Beckman Model F3 Oxygen Analyzer with ranges 0-5 percent, 0-15 percent, and 0-25 percent. Teledyne oxygen electrodes were also placed in the chamber for control of the oxygen make-up system at 0.3 atmospheres p02.

- 2.3.2 The oxygen in the chamber was maintained within the limits shown in Table I. Each block contains the mean and standard deviation describing the appropriate gas level for the indicated portion of the dive sequence. In general, the oxygen partial pressure was maintained near the 0.3-atmosphere level.
- 2.3.3 Chamber temperature and relative humidity were determined with thermistors and Luft Duratherm hygrometers. The air conditioning was set to maintain a comfortable temperature and a relative humidity of between 50-80 percent.
- 2.3.4 The carbon-dioxide level remained below 0.5 percent surface equivalent.

## 2.4 Gas Supply

2.4.1 Helium pressurization and oxygen make-up systems were installed in the chamber and igloo. Banks of cylinders containing pre-mixed helium-oxygen mixtures were available for emergency-mask breathing, treatment procedures or swimming with one of three types of underwater breathing apparatus. The gas mixture used with the different breathing apparatus was selected in such a manner as to provide a bag level of oxygen between 0.6 and 1.4 ATM during the swims/excursions.

## 2.5 Underwater Breathing Apparatus Used on the Dives

2.5.1 Three different types of breathing apparatus were used during the dive series: the Experimental Diving Unit Bank-Pack (which essentially consisted of a MK 6 semi-closed underwater breathing apparatus and a Garrahan Block (R), the MK 8 Mod 0, and the MK 9 semi-closed, mixed-gas, underwater breathing apparatus.

## 2.6 Watch Sections and Duties

- 2.6.1 Each twenty-four-hour watch section consisted of a Diving Officer, Chief of the Watch, a Diving Medical Officer, and a minimum of six additional personnel.
- 2.6.2 The Chief of the Watch supervised the operational aspects of the dive sequence assuring proper analysis and maintenance of the chamber environment and attending to the routine needs of the subjects. The Diving Officer was directly responsible for the safe conduct of all aspects of the dive, and the Diving Medical Officer was immediately available to handle any hazards or potential hazards to the subjects.

## 2.7 Records

- 2.7.1 Diving Log: An official diving log containing a chronological record of the dive procedure and significant events incident thereto was maintained throughout the dive.
- 2.7.2 Chamber Atmosphere Data Sheets: In addition to the official diving log, hourly readings of the chamber pressure, temperature, humidity, oxygen, and carbon dioxide were recorded on special log sheets designed for that purpose.

DIVE NO.	DESCENT	BOTTOM TIME	ASCENT
1	. 32	.31	.30
+	+.00	<u>+.</u> 0	<u>+.00</u>
2		.31	.30
		<u>+</u> . 02	+.00
3		.30	. 30
		<u>+</u> . 00	<u>+.01</u>
4		.31 +.02	.34
	.28	. 30	<u>+.</u> 08
5	+.01	<u>+</u> .00	<u>+</u> .08
,	.28	.30	.30
6	÷.00	<u>+</u> .01	<u>+</u> .01
2	.30	.30	.30
7	<u>+.01</u>	<u>+</u> .01	<u>+</u> .01
	. 30	.29	.30
8	<u>+</u> . 00	<u>+</u> . 02	<u>+</u> .01
9	. 30	.30	. 30
7	<u>+</u> .00	<u>+</u> . 01	<u>+</u> .01
10	.30	.31	.30
	<u>+.</u> 00	<u>+</u> .02	<u>+.01</u>
11	.30	. 32	• 30
	<u>+. 00</u>	<u>+.</u> 02	<u>+.01</u>
12	.29	.31	.30
	<u>+. 01</u>	<u>+. 01</u>	<u>+. 01</u>
13	.30 +.00	.30 +.00	.30 +.01
	<u>+</u> .00	<u> </u>	<u> </u>
14			
15	.29	.31	. 30
	<u>+</u> .00	<u>+</u> .02	<u>+.01</u>
16	.31	.30	. 30
10	<u>+</u> . 02	<u>+</u> .00	<u>+</u> .01
17	. 30	.30	.30
	<u>+. 01</u>	<u>+</u> . 00	<u>+.01</u>
18	.30	.30	. 30
	<u>+. 01</u>	<u>+. 01</u>	<u>+</u> . 00
19	.36	.31	. 30
	<u>+. 03</u>	+.03	<u>+</u> .01
20	.35	.30	.31
	±.04	<u>+. 02</u>	<u>+. 01</u>
21	.30 <u>+</u> .01	.30 .30 at $\div .01 + .00 825$	.30 +.00
22	.28 <u>+</u> .01	7 ±.01	.31 +.03
		.30	
23	.29 +.01	• 30 +• 01	.31 +.01
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#### 3. RESULTS

## 3.1 Saturation Dives with Excursions

- 3.1.1 The twenty-three saturation dives conducted during this series are listed by chronological order in Table II. Thirteen dives included excursions to deeper depths from the base saturation depth. The excursions were conducted from a variety of base depths, and totaled seventy-four man-excursions from the saturation depth. On three dives, excursions were conducted from each of two saturation base depths reached during the dive. The depth of the excursion, the number of team excursions (two men per team), and time at depth are listed under the column entitled "Excursions" in Table II. The critical time periods applicable to each of the twenty-three dives are summarized in Appendix A.
- 3.1.2 Experiments were conducted during dives, using a variety of compression rates (Appendix B). During the first four dives, the rapid rate of descent caused cases of mild compression arthralgia, and may have been a contributing factor to the cases of decompression sickness on three of the four dives. Commencing with Dive No. 5, a standard compression procedure was established and, with minor variations (Appendix B), remained the same throughout this series of saturation dives. After an initial descent was made to fourteen feet on air, compression to the final depth was accomplished, using pure helium at an average descent rate of 40 feet per hour (fph). This generally consisted of a fifteen-minute travel period and a forty-five-minute "compression" stop each hour.
- 3.1.3 Most of the dives were conducted with a minimum bottom time of twenty-four hours. Three dives, Numbers 1, 11, and 18, had bottom times of less than twenty-four hours (if the compression time is not counted as part of the bottom time).
- 3.1.4 Three saturation dives, Numbers 16, 17, and 21, involved remaining at the base depth for a minimum of twenty-four hours, conducting at least one excursion dive, and then "sliding" from the base depth to a new, deeper base depth. At least one excursion dive was then performed from the deeper base depth prior to commencing decompression. It was during dive No. 21, the third saturation dive of this "sliding" series, that a record-breaking dive was made by an excursion from the base depth of 825 feet to 1025 feet, for a bottom time of twelve minutes and thirty seconds.

Dive No.	Subjects	Date	Depth/Bottom Time	Excursions to Depth/Time (min)
1 *	4	Sep 66	200/23:34	300/60, 300/60
2	4	Nov 66	200/48	300/60, 300/62,
				300/60, 300/51
3	4	Nov 66	300/26	450/60, 450/60
4	4	Nov 66	450/27:30	600/60, 600/43
5	4	Jan 67	200/30:50	None
6	4	Feb 67	450/67:12	600/60, 600/64
7	4	Feb 67	450/55:28	600/60, 600/60
8	4	Mar 67	200/28:40	None
9	4	Mar 67	450/34:55	None
10	4	Apr 67	200/28:52	None
11*	4	Apr 67	450/13:05	None
12	. 4	Apr 67	200/46:48	300/60, 300/33
13	4	May 67	200/47:10	300/60, 300/60
14	4	May 67	200/28:40	None
15	4	Sep 67	450/52:46	600/60, 600/43
16	4	Sep 67	a. 200/29:25	300/58, 300/60
			b. 450/49:06	600/60, 600/60
17	4	Oct 67	a. 200/27:45	300/60, 300/50
			b. 450/51	600/60, 600/60
18 *	4	Oct 67	450/21:35	None
19	5	Jan 68	600/154:20	None
20	5	Jan 68	609/60:48	None
21	5	Feb 68	a. 600/44	825/19
			b. 825/54:03	1025/12::30
2.2	5	Mar 68	600/47:30	750/60
23	5	Apr 68	600/69:43	None

Table II.

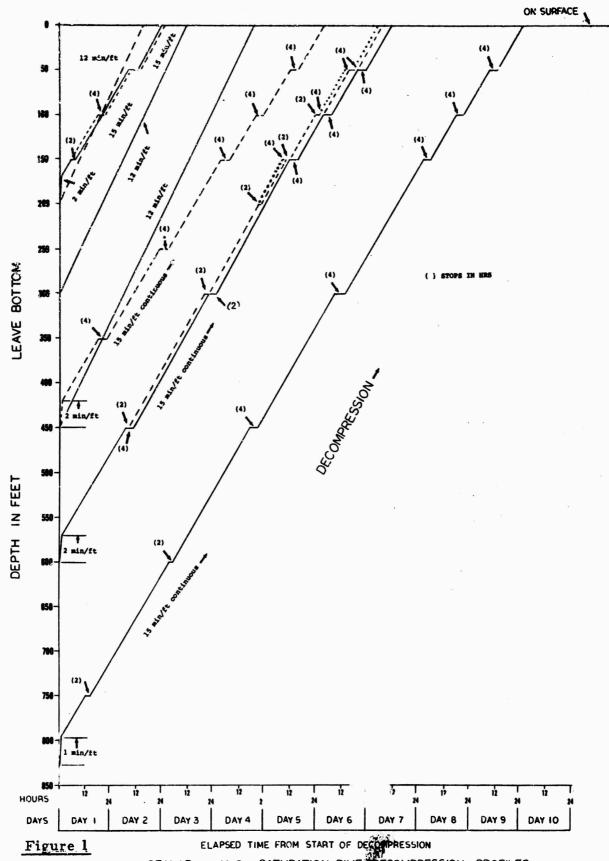
Chronological listing of the SEALAB III saturation dives conducted at EDU, with a listing of excursion dives.

<sup>\*</sup> Bottom times less than twenty-four hours.

3.1.5 The length and depth of each excursion dive varied according to the saturation depth and the purpose of the excursion. All were calculated to allow a no-decompression return to the saturation depth.

## 3.2 Decompression Schedule Development

- 3.2.1 During the early portion of the saturation-excursion dive series, (dives Nos. 1-4), the length of time between completion of the last excursion and commencement of decompression from the base depth was approximately five hours (Appendix A). This time period was gradually extended to a minimum of a twenty-four-hold at the base depth. The last group of dives with excursions (dives 16, 17, 21, and 22) used this format.
- 3.2.2 Appendix B and Table II provide a chronological cross-reference of the decompression developments by depth and date with regard to the initial rate of ascent from the base depth, other rates of ascent or deviations in rate of ascent experienced, and any decompression stops which may have been employed with a particular decompression schedule. Figure 1 provides a graphic presentation of all of the decompression profiles.
- 3.2.3 The incidence of decompression sickness was eight out of ninety-seven man-dives, as summarized in Table III. Of these cases, four occurred during decompression schedules based on a 5-fph rate of ascent without stops. No cases of decompression sickness were reported on eight dias with ascents from 450 feet at 4 fph, using the same stops as the SEALAB II. schedule. The other four cases occurred on deeper dives with the basic decompression rate of 4 fph. Complete Accident Reports (NAVMED 6420/1) are contained in Appendix D.



ELAPSED TIME FROM START OF DECOMPRESSION

SEALAB III HEO2 SATURATION DIVE PECOMPRESSION PROFILES

11

Dive No.	Diver	Decompression Sickness
1	Blackburn Meeks Sundstrom Wyatt	No symptoms. No symptoms. No symptoms Pain in left knee at depth of 8 feet. Dr. Bornman and LCDR Bergman accompanied R <sub>x</sub> of Wyatt in chamber.
3	Donaldson Garrahan Mullen Reedy	Pain in both knees at 50 feet. Spread to groin.  No symptoms. Accompanied R <sub>X</sub> of Donaldson.  Pain in left knee during Donaldson's treatment.  No symptoms. Accompanied R <sub>X</sub> of Donaldson.
4	Coffman Mandible Raymond, Dr. Stubbs	No symptoms. Accompanied $R_X$ of Stubbs. No symptoms. Accompanied $R_X$ of Stubbs. No symptoms. Accompanied $R_X$ of Stubbs. Pain in right knee; reported at 122 feet (occurred at 150 feet).
20	Bird Bornholdt Houle Moore Reando	No symptoms. Accompanied R <sub>x</sub> of Houle. No symptoms. Accompanied R <sub>x</sub> of Houle. Pain in right knee at 77 feet and recompression back to 115 feet. Recurrence during treatment. No symptoms. Accompanied R <sub>x</sub> of Houle. No symptoms. Accompanied R <sub>x</sub> of Houle.
22	Bunton Clark Lafferty Schmitt Tuckfield	No symptoms. Pain in left knee at 50 feet. Surface tender Reedy accompanied R <sub>x</sub> of Clark in chamber. Pain in left knee after surfacing. No symptoms. No symptoms.
23	Giese Jensen La Fontaine Lukeman Sutton	Pain in thigh at 50 feet.  No symptoms. Accompanied $R_X$ of Giese.

TABLE III Summary of decompression experience applicable to saturation dives of SEALAB III.

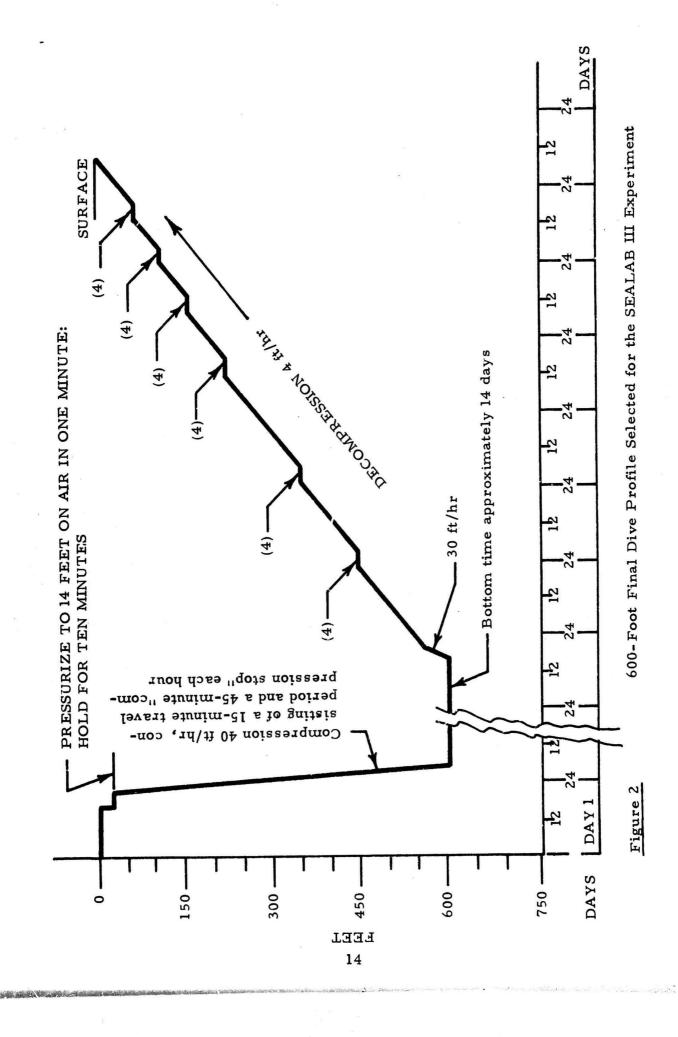
#### 4. DISCUSSIONS AND CONCLUSIONS

## 4.1 Decompression Experience

- 4.1.1 All ninety-seven man-saturation dives were successfully completed. In this sequence, eight cases of decompression sickness were recorded. All cases of decompression illness were successfully treated by recompression and the use of a high percentage of oxygen in the breathing medium.
- 4.1.2 Decompression schedules based on two primary rates of ascent were tested from various base depths in the process of evolving the schedule for use at SEALAB III. The selected schedule was more conservative than that used on the last three dives of the series to 600, 825, and 600 feet. The SEALAB III schedule was essentially that tested on eight dives to 450 feet, where no case of decompression sickness was experienced.
- 4.1.3 Nineteen of the saturation dives utilized a dive profile comparable to the profile which was finally selected for use with the SEALAB III experiment. In essence, they incorporated the slow compression rate, the basic four-foot-per-hour ascent rate, and a combination of decompression stops of two- or four-hour duration. The incidence of decompression sickness in this group was about 4.7 percent. Dives subsequent to this original series, but using similar dive profiles, experienced a much higher incidence of decompression sickness (9). The reasons for this difference are not entirely clear. However, the diver population utilized on the SEALAB III experiment was a highly-motivated and carefully-selected group participating in a personally-rewarding, classic voluntary program. Concern may have existed among the divers that decompression sickness would affect their participation in the final open-sea experiments. Casual interviews since the termination of the SEALAB III project suggest that at least a few cases of persistent joint pain during decompression did occur and were not reported.

## 4.2 SEALAB III Dive Profile

4.2.1 The final dive profile selected for use in the SEALAB III experiment is represented graphically in Figure 2. Upon descent to 14 feet on air, descent was



made at approximately average rate of 40 fph to the base depth of 600 feet using pure helium, with 45-minute stops every 40 feet. Bottom time was to be approximately fourteen days, and maintaining a partial pressure of oxygen at 0.30 atmospheres.

The dive profile consisted of a compression phase:

- Descent to 14 feet on air
- Descent to bottom on pure helium; 14 feet to 60 feet in fifteen minutes, stop for forty-five minutes, descend 40 feet in fifteen minutes, stop for forty-five minutes until on the bottom.

#### Bottom Time:

Fourteen days

## Decompression:

- Ascent from 600 feet to 570 feet continuous at 30 fph
- Ascent thereafter continuous at the rate of 4 fph, except for stops of four hours each at the six stage Jepths of 450, 350, 250, 150. 100, and 30 feet

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- 9. Summitt, J.K., Herron, J.M., and Flynn, E.T., Repetitive Excursion Dives from Saturated Depths on Helium-Oxygen Mixtures, Phase I: Saturation Depth 350 Feet, Research Report 2-70, US Navy Experimental Diving Unit, Washington, D.C., 15 March 1970.
- 10. Summitt, J.K., Alexander, J.M., Flynn, E.T., and Herron, J.M., Repetitive Excursion Dives from Saturated Depths on Helium Oxygen Mixtures, Phase II: Saturation Depths to 200 Feet and 150 Feet, Research Report 6-70, US Navy Experimental Diving Unit, Washington, D.C.. 23 September 1970.
- 11. Summitt, J.K., Alexander, J.M., and Flynn, E.T., Repetitive Excursion Dives from Saturated Depths on Helium-Oxygen Mixtures,

  Phase III: Saturation Depth 300 Feet, Research Report 7-70, US Navy
  Experimental Diving Unit, Washington, D.C., 23 September 1970.
- 12. Summitt, J.K., Alexander, J.M., and Flynn, E.T., Repetitive Excursion Dives from Saturated Depths on Helium-Oxygen Mixtures,

  Phase IV: Saturation Depths to 500 Feet and 600 Feet, Research Report 8-70, US Navy Experimental Diving Unit, Washington, D.C.,
  23 September 1970.

Dive No. and Depth	Excursion Depth	Left Surface	Reached Bottom Elapsed Time (Hrs:Min)	Commenced Decompression Elapsed Time (Hrs:Min)	Reached Surface Elapsed Time (Hrs:Min)	Total Decompression Time (Hrs:Min)
1 200 ft	300 ft	1788 4 Sep 1966	92:00	24:00	65:16	4i:16
2 200 ft	300 ft	1830 7 Nov 1966	00:20	48:00	89:17	41:17
5 200 ft	300 ft	0739 26 Jan 1967	04:50	30:50	82:20	51:30
8 200 ft	8	0900 9 Mar 1967	04:40	28:40	81:10	51:30
10 200 ft	•	1034 5 Apr 1967	04:40	28:52	80:22	51:30
12 200 ft	300 ft	1558 25.Apr 1967	10:40	46:48	98:18	51:30
13 200 ft	300 ft	1611 8 May 1967	04:40	47:10	98:40	51:30
14 200 ft		0837 16 May 1967	04:40	28:40	80:10	51:30

APPENDIX A Summary of case 1 of SEALAB II

Summary of critical time periods applicable to saturation dives of SEALAB III (at EDU) in order of depth.

Dive No. and Depth	Excursion Depth	Left Surface	Reached Bottom Elapsed Time (Hrs:Min)	Commenced Decompression Elapsed Time (Hrs:Min)	Reached Surface Elapsed Time (Hrs:Min)	Total Decompression Time (Hrs:Min)
16a 200 ft	300 ft	1402 22 Sep 1967	04:40	Compression from 20 time 29:25 (Hrs:Min)	Compression from 200 ft to 450 ft began at elapsed time 29:25 (Hrs:Min)	began at elap्र≪र्त
16b 450 ft	# 009		35:40	78:31	204:31	126:00
17a 200 ft	300 ft	1347 3 Oct 1967	04:40	Compression from 20 time 27:45 (Hrs:Min)	Compression from 200 ft to 450 ft began at elapsed time 27:45 (Hrs:Min)	began at elapsed
17b 450 ft	£009		34:00	78:45	204:45	126:00
3 300 ft	450 ft	1830 14 Nov 1966	00:28	26:00	119:05	93:05
4 450 ft	# 009	1554 28 Nov 1966	01:26	27:30	150:37	123:07
6 450 ft	£ 009	1956 2 Feb 1967	10:56	67:12	193:12	126:00
7 450 ft	f 009	0817 16 Feb 1967	10:55	55:28	181:28	126:00

Summary of critical time periods applicable to saturation dives of SEALAB III (at EDU) in order of depth. APPENDIX A
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Dive No. and Depth	Excursion Depth	Left Surface	Reached Bottom Elapsed Time (Hrs:Min)	Commenced Decompression Elapsed Time (Hrs:Min)	Reached Surface Elapsed Time (Hrs:Min)	Total Decompression Time (Hrs:Min)
9 450 ft		0903 16 Mar 1967	10:55	34:55	160:55	126:00
11 450 ft	1	0858 11 Apr 1967	10:55	24:00	150:40	126:40
15 450 ft	¥ 009.	0900 12 Sep 1967	10:55	52:46	178:46	126:00
18 450 ft	1	1141 16 Oct 1967	10:55	32:30	158:30	126:00
19 600 ft	1	0854 10 Jan 1968	14:07	154:20	317:21	163:00
20 600 ft	•	0852 29 Jan 1968	14:12	60:48	232:03	171:15
21a 600 ft	825 ft	1547 16 Feb 1968	14:07	Compression from 6 time 44:00 (HreiMin)	Compression from 600 ft to 825 ft began at elapsed time 44:00 (Hrs:Min)	began at elapsed
21b 825 ft	1025 ft		49:10	98:03	321:33	223:30

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Summary of critical time periods applicable to saturation dives of SEALAB III. (at EDU) in order of depth,

Total Decompression Time (Hrs:Min)	159:30	159:31			
Reached Surface Elapsed Time (Hrs:Min)	207:00	229:14			
Commenced Decompression Elapsed Time (Hrs:Min)	47:30	69:43			
Reached Bottom Elapsed Time (Hrs:Min)	14:08	9:45	·		
Left Surface	1542 20 Mar 1968	222 <del>4</del> 15 Apr 1968			
Excursion Depth	750 ft	1			
Dive No. and Depth	22 600 ft	23 600 ft			

Summary of critical time periods applicable to saturation dives of SEALAB III (at EDU) in order of depth,

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DECOMPRES- SION STOPS	None	2-ft incre- ments at 25-min/stop	150'/2 hrs 50'/4 hrs	100'/4 hrs 50'/4 hrs	100'/4 hrs 50'/4 hrs	100'/4 hrs 50'/4 hrs
DECOMPRESSION RATE TO DEPTH (ASCENT FPH)	5 fph to surface: contin- uous decompression	5 fph to surface: staged decompression	4 fph to surface: continuuous decompression, except as noted	30 fph to 170 ft; 4 fph to surface: continuous decompression, except as noted	30 fph to 170 ft: 4 fph to surface: continuous decompression, except as noted	30 fph to 170 ft: 4 fph to surface: continuous decom- pression, except as noted
COMPRESSION RATE/GAS/TO DEPTH	**::30/AIR/14' 7.6 fpm/He /200	1::55/AIR/14' 12.1 fpm/He /200	1::35/AIR/14' 40 fpm/He /200	2::00/AIR/14' 40 fph/He /200	4::00/AIR/14' 40 fph/He /200	::25/AIR/14' 40 fph/He /200
DATE	Sep 1966	Nov 1966	Jan 1967	Mar 1967	Apr 1967	Apr 1967
DIVE NO./ DEPTH	1 200 ft	2 200 ft	5 200 ft	8 200 ft	10 200 ft	12 200 ft

\*Descent will be continuous unless otherwise noted. Descent rates are approximations (i.e., +1 fph). \*\*The time required for compression to 14 feet on AIR will be given in minutes and seconds (0::00), instead of feet per hour.

Description of the Compression and Decompression Profiles used on the SEALAB Saturation Dives at EDU, in order of depth.

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DECOMPRES- SION STOPS	100'/4 hrs 50'/4 hrs	100'/4 hrs 50'/4 hrs	350'/4 hrs 250'/4 hrs 150'/4 hrs 100'/4 hrs 50'/4 hrs	350'/4 hrs 250'/4 hrs 150'/4 hrs 100'/4 hrs 50'/4 hrs	None	None
DECOMPRESSION RATE TO DEPTH (ASCENT FPH)	30 fph to 170 ft; 4 fph to surface; decompression	30 fph to 170 ft; 4 fph to surface; decompression	30 fph to 420 ft; 4 fph to surface; staged decom-pression	30 fph to 420 ft; 4 fph to surface; staged decom- pression	5 fph to 102 ft; 3 fph to 76 ft; 5 fph to surface	5 fph to surface; continuuous
COMPRESSION RATE/GAS/TO DEPTH	1::05/AIR/14' 40 fph/He /200	2::00/AIR/14' 40 fph/He /200	6::00/AIR/14' 40 fph/He /200 40 fph/He /450	2::00/AIR/14' 40 fph/He /200 40 fph/He /450	1::15/AIR/14' 13.1 fpm/He /300	::32/AIR/14' 60 fpm/He /450
DATE	May 1967	May 1967	Sep 1967	Oct 1967	Nov 1966	Nov 1966
DIVE NO./ DEPTH	13 200 ft	14 200 ft	16 200 ft 450 ft	17 200 ft 450 ft	3 300 ft	4 450 ft

\*Descent will be continuous unless otherwise noted. Descent rates are approximations (i.e., +1 fph). \*\*The time required for compression to 14 feet on AIR will be given in minutes and seconds (0::00), instead of feet per hour.

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Description of the Compression and Decompression Profiles used on the SEALAB Saturation Dives at EDU, in order of depth.

MPRES- STOPS	hrs hrs hrs	hrs hrs hrs	hrs hrs hrs	hrs hrs hrs	assas sesses	4444 8 2 2 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
	350'/4 250'/4 150'/4 100'/4 50'/4	350'/4 250'/4 150'/4 100'/4 50'/4	350'/4 250'/4 150'/4 100'/4 50'/4	350'/4 250'/4 150'/4 100'/4 50'/4	350'/4 250'/4 150'/4 100'/4	350'/4 250'/44 150'/4 50'/4
DECOMPRESSION RATE TO DEPTH (ASCENT FPH)	30 fph to 420 ft; 4 fph to surface; staged decompression	30 fph to 420 ft; 4 fph to surface; staged decom-pression	30 fph to 420 ft; 4 fph to surface; staged decom-pression	30 fph to 420 ft; 4 fph to surface; staged decompression	30 fph to 420 ft; 4 fph to surface; staged decom- pression	30 fph to 420 ft; 4 fph to surface; staged decom-pression
COMPRESSION RATE/GAS/TO DEPTH	::45/AIR/14' 40 fph/He /450	::40/AIR/14' 40 fph/He /450	1::00/AIR/14' 40 fph/He /450	::37 /AIR/14' 40 fph/He /450	2::00/AIR/14' 40 fph/He /450	6::00/AIR/14' 40 fph/He /450
DATE	Feb 1967	Feb 1967	Mar 1967	Apr 1967	Sep 1967	Oct 1967
DIVE NO./ DEPTH	6 450 ft	7 450 ft	9 450 ft	11 450 ft	15 450 ft	18 450 ft

\*Descent will be continuous unless otherwise noted. Descent rates are approximations (i.e., +1 fph). \*\*The time required for compression to 14 feet on AIR will be given in minutes and seconds (0::00), instead of feet per hour. Description of the Compression and Decompression Profiles used on the SEALAB Saturation Dives at EDU, in order of depth.

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DIVE NO./ DEPTH	DATE	COMPRESSION RATE/GAS/TO DEPTH	DECOMPRESSION RATE TO DEPTH (ASCENT FPH)	DECOMPRES. SION STOPS
19 600 ft	Jan 1968	1::00/AIR/14' 90 fph/He /60 Staged descent; 15-min travel period and 45-min compres- sion stop each hour there- after	30 fph to 570 ft; 4 fph to surface; staged decom- pression	450'/4 hrs 300'/4 hrs 150'/4 hrs 100'/4 hrs 50'/4 hrs
20 600 ft	Jan 1968	1::00/AIR/14' 40 fph/He /20' Staged descent; 15-min travel period and 45-min compression stop each hour there	30 fph to 570 ft; 4 fph to 77 ft; staged decompression. Decompression illness - see Table III and NAVMED 6420/1	450'/4 hrs 300'/4 hrs 150'/4 hrs 100'/4 hrs 50'/4 hrs
21 600 ft 825 ft	Feb 1968	2::00/AIR/14' 160 fph/He /690	60 fph to 795 ft; 4 fph to surface; staged decom- pression	750'/2 hrs 600'/2 hrs 450'/4 hrs 300'/4 hrs 150'/4 hrs 100'/4 hrs 50'/4 hrs
22 600 ft	Mar 1968	00/AIR ph/He	30 fph to 570 ft; 4 fph to 50 ft; staged decompression. Decompression illness - see Table III and NAVMED 6420/1	450'/2 hrs 300'/2 hrs 200'/2 hrs 150'/2 hrs 100'/4 hrs 50'/4 hrs
23 600 ft	Apr 1968	3::00/AIR/14' 600 fph/He /220 60 fph/He /280 160 fph/He /600 Staged descent; random stops to 280 ft. Then commenced 45	fph/He /220 fph/He /220 fph/He /280 fph/He /600 descent; random stops ft. Then commenced 45-min stop every 40 feet.	450'/2 hrs 300'/2 hrs 150'/4 hrs 100'/2 hrs 50'/4 hrs
*T		C Loton contractor contractor contractor	the section section Decrease makes and consistent of	

\*Descent will be continuous unless otherwise noted. Descent rates are approximations (i.e., +1 fph).
\*\*The time required for compression to 14 feet on AIR will be given in minutes and seconds (0::00), instead of feet per hour.

Description of the Compression and Decompression Profiles used on the SEALAB Saturation Dives at EDU, in order of depth.

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DIVE No.	DIVER	RANK/ RATE	AGE (YEARS)	HEIGHT (INCHES)	WEIGHT (POUNDS)	CLASS DIVER
1	Blackburn	A01	27	74		First
	Meeks	BM1	34	75	200	First
	Sundstrom	MMCS	34	69	•	First
	Wyatt	ВМС	37	70	186	First
	Blackburn	A01	27	74	-	First
	Coffman	TMl	37	73	200	First
2	Raymond, Dr.	Lt.	31	72	•	Medical Officer
	Stubbs	SF2	29	70-1/2	-	First
	Donaldson	HMl	-	-	-	Medical DV Tech
	Garrahan	W01	30	70	160	HeO <sub>2</sub> DV Officer
3	Mullen	ВМ1	2.7	64	160	First
	Reedy	HM1	25	67-1/2	165	Medical DV Tech
	Coffman	TM1	37	73	200	First
	Mandible	GMG1	32	69	170	First
4	Raymond, Dr.	Lt.	31	72	-	Medical Officer
	Stubbs	SF2	29	70-1/2	-	First

APPENDIX C
Page 1
Descriptive physical data on each of the divers who participated in the saturation dives of SEALAB III (1966-1968).

DIVE No.	DIVER	RANK/ RATE		HEIGHT (INCHES)	•	CLASS DIVER
5	Huss	DC1	25	69	168	First
	Lazaro	EN2	39	69	154	First
	Morey	EM1	27	72	194	First
	Mulally	DC1	33	72-1/2	175	First
	Barth	cwo	36	71	190	HeO <sub>2</sub> DV Officer
	Blackburn	AO1	27	74	-	First
6	Mesplay	SFC	29	69	-	First
	Reedy	HM1	25	67-1/2	165	Medical DV Tech
7	Huss	DC1	25	69	168	First
	Meeks	BM1	35	75	200	First
	Morey	EM1	27	72	203	First
	Wells	MNCS	40	68-1/2	164	First
·	Cannon	Civilian	31	68-1/2	170	-
	Jenkins	Civilian	31	71-3/4	183	-
8	Jones	Lt.	34	73	235	Medical DV Officer
	Waller	Civilian	33	68	152	-

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Descriptive physical data on each of the divers who participated in the saturation dives of SEALAB III (1966-1968).

		<del></del>	,			
DIVE No.	DIVER	RANK/ RATE	AGE (YEARS)	HEIGHT (INCHES)	WEIGHT (POUNDS)	CLASS DIVER
9	Cannon	Civilian	31	68-1/2	170	-
	Jenkins	Civilian	31	71-3/4	183	-
	Pratt	DC2	24	78	282	First
	Waller	Civilian	33	68	152	•
	Cooper	Civilian	30	69	180	•
10	Harrell	Civilian	29	68	130	<b>-</b>
	Pruna	Civilian	26	74	190	. •
	Wyatt	вмс	38	70	186	First
	Cooper	Civilian	30	69	180	•
	Harrell	Civilian	29	68	130	-
11	Kennedy	ST1	35	72	180	First
	Pruna	Civilian	26	74	190	•
5.5						
nte e	Bussey	Lt.	29	72	180	HeO <sub>2</sub> DV Officer
	Eaton	GMG1	41	68	168	First
12	Mandible	GMG1	32	69	170	First
	Moynan	Lt.	29	72	170	Medical Office

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Descriptive physical data on each of the divers who participated in the saturation dives of SEALAB III (1966-1968).

DIVE No.	DIVER	RANK/ RATE	AGE (YEARS)	HEIGHT (INCHES)	WEIGHT (POUNDS)	CLASS DIVER
	Conda	TM1	34	68-1/2	170	First
13	Ramsey	PH2	33	70-1/2	150	First
	Reaves	PH1	38	71-1/2	185	First
	Rudin	ВМ1	34	73	150	First
	Bunton	Civilian	33	72	180	•
	Dowling	Civilian	40	71	175	•
14	Hendrey	нмі	32	66	-	First
	Stevens	Civilian	37	74	190	•
	Bussey	Lt.	30	72	175	HeO2 DV Officer
	Eaton	GMG1	41	68	165	First
15	Ramsey	PH2	33	70-1/2	148	First
	Reaves	PHI	38	71-1/2	185	First
	Buski	SF1	34	72	195	First
	McDole	LCDR	39	70-1/2	178	HeO <sub>2</sub> DV Officer
16	Myers	MM1	23	68-1/2	162	First
	Vorosmarti	LCDR	31	71	160	Medical Officer

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Descriptive physical data on each of the divers who participated in the saturation dives of SEALAB III (1966-1968).

DIVE No.	DIVER	RANK/ RATE	AGE (YEARS)	HEIGHT (INCHES)	WEIGHT (POUNDS)	CLASS DIVER
-	Armstrong	HM1	25	70	150	First
	Eggar	Lt.	41	70	175	HeO <sub>2</sub> DV Officer
17	Melder	EQCM	33	68	175	First
	Schleigh	BUC	32	69	162	First
	Dowling	Civilian	40	71	165	-
	Hallanger	Civilian	28	73	165	-
18	Osborn	LCDR	29	70	180	HeO <sub>2</sub> DV Officer
	Robinson	Civilian	26	72	160	· •
	Bradley	Lt.	31	_	-	Medical Officer
	Garrahan	WO1	30	70	160	HeO2 DV Officer
19	Morey	EM1	28	72	203	First
	Shipp	Lt.		•	-	HeO <sub>2</sub> DV Officer
	Wells	MNCS	41	68-1/2	164	First
	Bird	EN1	30	71	205	First
	Bornholdt	Lt.	30	-	•	HeO <sub>2</sub> DV Officer
20	Houle	вм1		-	<del>-</del>	First
	Moore	мм2	26	74-1/2	205	First
	Reando	MR1	31	71	174	First

APPENDIX C Descriptive physical data on each of the divers who participated in the saturation dives of SEALAB III (1966-1968).

DIVE No.	DIVER	RANK/ RATE	AGE (YEARS)	HEIGHT (INCHES)	WEIGHT (PCUNDS)	CLASS DIVER
	Conda	TMl	34	68-1/2	170	First
	Kleckner	HM1	<b>2</b> 6	72	155	-
21	Lugo	MM1	26	67	170	First
	Risk	мм2	31	69	155	First
	Winters	EN1	-	•	•	First
	Bunton	Civilian	33	72	180	-
	Clark	PO1	34	70	165	Royal Navy (British)
22	Lafferty	Lt.	30	69	170	Royal Navy (British)
	Schmitt	ммс	29	70	150	First
	Tuckfield	ENCS	<b>4</b> 6	-	-	First
	Giess	LCDR	31	-	-	HeO <sub>2</sub> DV Officer
	Jensen	EN1	24	-	-	First
23	LaFontaine	LCDR	34	69	180	Canadian Navy
	Lukeman	LSCD	28	36	175	Canadian Navy
	Sutton	Lt.	28	-	-	Australian Navy

APPENDIX C Descriptive physical data on each of the divers who participated in the saturation dives of SEALAB III (1966-1968).

# APPENDIX D

NAVMED 6420/1 REPORTS

(Reports of Decompression Sickness and all Diving Accidents)

3HD- P&PO

0003475

REPORT OF DECOMPRESSION SICKNESS AND ALL DIVING ACCIDENTS ORIGINAL - TO PUMED, WASHINGTON. B. C. BAYMED-BIG (REV. 2-56) COPY - TO EXP. DIVING UNIT, MAYAL GUN FACTORY. WASHINGTON MAVY YARD, WASHINGTON, D. C. 20390 14 Nov 1966 TOEN-IFICATION NUMBER 787 73 57 WYATT, Frank McClain BM (DV) USN DIVING QUALIFICATIONS (Check one) AGE WEIGHT HEIGHT BUILD (Check one) MENDEN MED. MEAVY OBESE 100 UWS STU 175 38 RECORD OF ALL DIVES MADE DURING THE TWELVE HOURS PRECEDING THE ACCIDENT [1] more than three dives were made, record additional under "RENARKS" on reverse.) FIRST DIVE JE Sep 1966 included ( SECOND DIVES Sep 1960 DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME THIRD DIVE TYPE OF DIVE DEPTH OF DIVE DEPTH OF DIVE BOTTOM TIME BOTTOM TIME TYPE OF DIVE DRY WET 300 rest 200 reet 2h hrs 60min TYPE OF EQUIPMENT TYPE OF EQUIPMENT TYPE OF EQUIPMENT OPEN CLOSED CIRCUIT SCUBA SCUBA CLOSED CIRCUIT SCUBA DEEP SEA HELIUM DEEP CHAMBER MARK VI HACK PACK TYPE OF WORK TYPE OF WORK TYPE OF WORK HODERATE 3000 BREATHING MEDIUM BREATHING MEDIUM BREATHING MEDIUM MELIUM S DAYGER S DAYGER OTHER (Specify) AIR HELIUM S DAYGER S DAYGER OTHER (Specify) AIR HELIUM S DAYGER S DAYGER OTHER (Specify) 96 SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM RELIUM-DAYGEN GASOLINE OTHER AIR BANKS MELIUM-OXYGEN GASOLINE COMPRESSOR AIR BANKS HELIUM-ORYGEN GASOLINE COMPRESSOR AUTOMATIC MIXING OF HE &O2 DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE STANDARD SI'RFACE USING NE. DECOMPR. TABLE USED STANDARD SURFACE USING ME. DECOMPR. STANDARD SURFACE USING ME. DECOMPR. TABLE USED AIR OXIGER NO DECOMPRESSION AIR DAYGER SATURATION P.P. P.P. ... TIME REACHED 200 TIME REACHED BOTTOM RATE OF ASCENT FU 200 1248 1814 60 FT/HIR **17**48 1147 1149 If surface decoupression used, time from If surface decoupression used, time from If surface decompression used, time from last water stop to 1st chapter stop. last unter stop to 1st chamber stop. last water stop to 1st chamber stop. WATER WATER DEPTH WATER CHAMBER CHAMBER OF STOP OF STOP MINUTES BREATHING AT STOP MEDIUM MINUTES BREATHING AT STOP MEDIUM (feet) (feet) (feet) 210 210 210 200 200 200 190 190 190 180 180 180 170 170 170 -16b 160 160 LOR 150 150 150 140 140 130 130 130 120 120 120 110 110 110 100 100 100 96-1 90 90 80 80 7012/38 70 70 60 60 50 50 40 40 40 30 30 30 20 20 20 10 10 10 28

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			SIGNS AND SYMPTOMS BEFORE TREATMENT	
	ONS	ET	AMATOMICAL LOCATION	INTENSITY
	DATE	TIME	ANATOMICAL LOCATION	(MILD, MOD., SEVERE)
OCALIZED PAIN	7 Sep	p643	Right knee	mild
RASH				
MUSCULAR WEAKNESS				
NUMBNESS			20 to 1 1/2	
DIZZINESS				
VISUAL DISTURBANCES				
PARALYSIS				
UNCONSCIOUSNESS				
DYSPNEA (CHOKES)	r*			d
NAUSEA OR VOMITING				
MUSCULAR TWITCHING				
RESTLESSNESS				
CONVULSIONS				
ACOUSTIC AURA				
PARESTHESIA				I

REMARKS: lother signs and symptoms before, during and following treatment)

Bend under pressure while undergoing decompression from saturation: excursion dive. "Stiff" knee from known trauma at 0643 and 22 feet. Definite pain at 0926 and 8 feet. Treatment started from 8 feet gauge.

			TREATME	NT SCHEDULE				REC	URRENCE TRI	EATHENT S	CHEDULE	
LEF	T THE	ROMEN 8	feetREL	IEF	TIME REACHED BOTTOM	LEI	FT SURF	ACE	REL	IEF	TIME REACHED BUTTOM.	
ATE Sop	TII		0954	40 ft.	60 Ft- 0956	DATE	TII	HE	TIME	DEPTH		
TIME	ON BO	TIOM	REACHED	SURFACE	TREATMENT TABLE USED	TIME	ON HO	TOM	PEACHED	SURFACE	TREATMEN	TABLE HISED
		MID.	7 Sep	1211	Short oxygen			wie,	DATE	TIME		
	H OF				BER treatment table 3 or 4 is that tables are altered)		H OF				BER traatment tabl ment tables are	
FEET	ET LBS MINUTES AT STOP				HREATHING MEDIUM	FEE1	LOS	M	NUTES AT S	TOP	BREATHIN	G MEDIUM
165	73.4					165	73.4					
140	62.3					140	62.3					
120	53.4					120	53.4					
100	44.5					100	44.5					
80	35.6					80	35.6					
60	26.7					60	26.7					
50	22.3					50	22.3					
40	17.8					40	17.8					
30.	13.4					30	13.4					
20	8.9					20	8.9					
10	4.5					10	4.5					
TO SU	RFACE				-	70 S	URFACE					

REMARKS: (Include saquence of events preceding the accident and subsequent result of treatment, noting any unusual contributing factors - Use continuation sheet of needed)

SEE ATTACHED SHEET

R.C. Bonwaun

R. C. BORNMANN, CDR, MC, USN SENIOR MEDICAL OFFICER

SIGNATURE OF MEDICAL DEPARTMENT REPRESENTATIVE

This 38 year old Diver First Class was one of four divers participating in the first developmental dive with chamber saturation for 24 hours at 200 feet on helium-oxygen and excursions to 300 feet in the wet pot. Decompression from 200 feet was at the rate of 2 feet every 25 minutes with a planned total of 41 hours. On the evening of the second day of decompression, with the chamber at approximately 60 feet, WYATT bumped his right knee climbing into a hammock. Awakened at 0630 the next morning (24 feet) he reported that the knee was "stiff". Two hours and 43 minutes later, when the chamber was 8 feet, the knee was definitely aching. The other three divers were without symptoms and were transferred to the Igloo where the original schedule was followed without incident to the surface. WYATT was kept in the chamber. The atmosphere was flushed with air and he began to breathe oxygen. He was taken to 60 feet. Relief was complete as the chamber went past 10 feet. Pressure schedule followed profile of short Oxygen Treatment Schedule so surface, which was reached at 1211 on Wednesday 7 September, one hour and seven minutes later than the other three divers.

COMMENT: Appearance of bends at this site is felt to be directly related to the trauma mentioned and to the abnormal tissue condition which was produced. Diver's age is also noted, although this is not felt to be unusually significant. No change in decompression schedule for these saturation dives is contemplated as the result of this accident. Incident was valuable exercise in treating bends during saturation decompression, but was also quite simple as a result of the fact that pain occurred so close to the surface. Other three divers were able to complete last 75 minutes in Igloo. This would not have been possible, due to lack of complete life support and comfort facilities there, if decompression were to extend much longer.

R. C. BORNMANN Commander, Medical Corps U. S. Navy

NOT REPRODUCIBLE

# REPORT OF DECOMPRESSION SICKNESS AND ALL DIVING ACCIDENTS

REPORTS SYMBOL: MED-6420-1

HAVMED 6420/1 (REV. 3-67) DRIGINAL - BUMED, WASHINGTON, D. C.
COPY - NAVY FXP. DIVING UNIT, WASHINGTON NAVY YARD, WASHINGTON, O. C.
COPY - NAVAL SUB. MED. CENTER, NAVAL SUB. HASE NEW LONDON, GPOTON, CONN. S N. 0105 - 214 - 1650 NAME AND ADDRESS OF REPORTING STATEON Navy Experimental Diving Unit, Bldg. 214, WNY, Washington, D.C. 19 NOV 1966 NAME OF PATRIAL (Surnage first) GRADE/RATE | IDENTIFICATION NO. BM(1) MULLEN James E. 494 95 62 Poss. Decompression Sickness WEIGHT HEIGHT BUILD (Check one) AGE DIVING QUALIFICATIONS (Check one) LENGER MED THE AVY OBESE STU UWS 27 160 ĪNS YRS. RECORD OF ALL DIVES MADE DURING THE TWELVE HOURS PRECEDING THE ACCIDENT three dives were made, record additional under "REMARKS" on reverse.) FIRST DIVE THIRD DIVE SECOND DIVE TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME DRY WET 300 min. 1551 feet min. feet TYPE OF EQUIPMENT TYPE OF EQUIPMENT TYPE OF LOUIPMENT DELP DIEP SIÀ HELIUM GPIN CIRCUIT SCUBA CLOSED CERCHET SCUBA DITP SIA HELIUM OPIN CIRCUIT SCUBA CLOSED CIRCUIT SCUBA DI I P CI (141) CIRCUIT SCURA OTHER CHAMBER TYPE OF WORK TYPE OF WORK TYPE OF WORK MODERATE HODERATE MODERATE BREATHING MEDIUM BREATHING MEDIUM BREATHING MEDIUM DXYGEN OTHER (Specify) HELIUM & OXYGEN & OXYGEN % OXYGEN % OXYGEN 85.9% He, 11.1% N2, 3% O2 SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM HELICM-OXYGEN GASOLINE BANKS GASOLINE AIR BANKS HELIUM-OXYGEN GASOLINE COMPRESSOR HELIUM-OXYGEN GASOLINE COMPRESSOR X DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE STANDARD SURFACE USING HE. DECOMPR. TABLE USED SURFACE USING HE. DECOMPR. TABLE USED SURFACE USING HE. DECOMPR. OXYGEN OXYGEN SATURATION TIME REACHED TIME REACHED RATE OF ASCENT TO FIRST STOP TIME REACHED SURFACE RATE OF ASCENT TO FIRST STOP TIME RATE OF ASCENT TIME REACHED BOTTOM REACHED BOTTOM 14 NOV 14 NOV See 1830 1858 19 NOV 1726 If surface decompression used, time from If surface decompression used, time from If surface decompression used, time from last water stop to 1st chamber stop. last water stop to 1st chamber stop. last water stop to 1st chamber stop. DEPTH DEPTH DEPTH CHAMBER WATER CHAMBER WATER CHAMBER WATER OF STOP OF STOR MINUTES BREATHING AT STOP MEDIUM MINUTES BREATHING AT STCP MEDIUM OF STOP MITUTES BREATHING MINUTES BREATHING AT STOP MEDIUM BREATHI (feet) (feet) 210 210 200 200 200 190 190 190 SEE ADDENDUM 180 180 180 170 170 170 160 160 160 150 150 150 140 140 140 130 130 130 120 120 120 110 110 110 100 100 100 90 90 90 80 80 80 70 70 70 60 60 60 50 50 40 40 40 30 30 30 20 20 20 10 10 10

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REMARKS: (other signs and symptoms before, during and following treatment)

#### SEE ADDENDUM

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REMARKS: (Include sequence of events preceding the accident and subsequent result of treatment, noting any unusual contributing factors - Use continuation sheet i, needed)

SEE ADDENDUM

• .:::::

J. K. SUMMITT, CDR, MC, USN
SIGNATURE OF MEDICAL DEPARTMENT REPRESENTATIVE

MULLEN was one of 4 divers making a saturation dive to 300 feet with an excursion dive to 450 feet for one hour. The dive began at 14 NOV 66. Decompression was carried out in 2 foot steps, spending 25 minutes at each stop. The chamber atmosphere at 300 feet consisted of 3% Oxygen, 11.1% Nitrogen, and 85.9% Helium. During decompression the oxygen level was maintained at 0.3 atmospheres.

One of the other divers experienced a pain only bend at the 50 foot level and MULLEN accompanied the recompression treatment back to 108'. Decompression from this level was at 20 MPF. At 90 feet, MULLEN reported a tense sensation in the left knee and was treated with two 30 minute periods of breathing 60-40 helium-oxygen mixture by mask while continuing decompression. Subjectively, he reported slight improvement following these periods. Decompression was continued to the surface without any change in his symptoms.

IMPRESSION: Possible mild decompression sickness.

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					SIGNS AND SYMPTOMS BEFORE TREATMENT			
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RESTLESSNESS								
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TO SI	URFACE					TO S	URFAC	E				

REMARKS: (Include requence of events preceding the accident and subsequent result of treatment, noting any unusual contributing factors - Use continuation sheet if needed)

C. J. RUBENSTEIN, LT, MC, USIR

#### **VDDE:IDIT!**

DOMADSON was one of four divers making a saturation dive to 300° with an excursion dive to 450° for 1 hour. The dive began on 14 November 1966. Decompression was carried out in 2 foot steps, spending 25 minutes at each stop. The chamber atmosphere at 300° consisted of 3.0% oxygen, 11.1% nitrogen, and 85.0% helium. During the decompression the oxygen level was maintained at 0.3 atmosphere, the pressure being maintained, as needed, with 100% helium. CO2 was not allowed to exceed .05%. The gas mixture for the 450° excursion was 6% oxygen/92% helium.

The pre-dive physical examination was unremarkable. DOMALDSCH had been treated for left knee pain during a dive to 400 feet for 1 hour on 6 October, and for right knee pain during a dive to 450 feet for 1/2 hour on 11 October. On 25 October he made a 100 foot saturation dive, with a 200° excursion, without incident.

At 52:02::30 from the start of decompression, at 50°, DOMALDSON reported moderate pain behind the patellae of both knees. The pain had begun minimally at 54°, and had increased in intensity after the progression to 52 and to 50. Physical examination by REEDY, HELDY, a member of the 4-man team, under the direction of the medical officer, was unremarkable. Recompression was begue, with the patient breathing 20% C2, 30% He by mask. At 60° the pain was slightly decreased. At 70° the retro-patellar pain was nearly gone, but he began having pain in the right calf and right popliteal fossa. The patellar pain disappeared at 80%, but the right calf pain increased in intensity and extended down the leg. Re-examination at 80°, again under the direct supervision of the attending M.D., revealed slight weakness of the right leg. The pain was increased by neck flexion. Sensation was intact, deep tendon reflexes equal bilaterally, plantar responses normal, and the femoral and pedal pulses were intact and equal bilaterally. The pain increased transitorily as the recompression was continued to 90%, with the addition of some pain in the right groin.

The transition to 100° was not accompanied by additional pain. At this depth the pain became intermittent, primarily involving the right calf, popliteal fossa, and groin areas. Re-examination was normal except for minimal weakness of the right leg. (The apparent weakness may have been due to pain). He spent two 30 minute periods breathing 50%/20% HeO2 by mask, with 10 minute intervals breathing chamber atmosphere. At the end of this time the pain was present in the right knee and occasionally in the left knee. The physical examination was normal, and he had only minimal subjective knee weakness after doing 5 deep knee bends. He then spent two 30 minute periods breathing 60% He/40% O2 by mask, with 10 minute intervals breathing chamber atmosphere. Very slight pain and stiffness were present in the right knee at the end of this time, and occasional slight pain in the left knee.

NOT REPRODUCIBLE

It was decided to proceed to 110° to achieve more nearly complete relief. The pain increased in intensity as the pressure was increased, however, with pain returning in the right groin. The recompression was stepped at 106° because of the pain. Physical examination revealed no neurological deficit. After 30 minutes breathing chamber atmosphere, he was put on 60% helium, 40% oxygen by mask for two 30 minute periods, with an interval period of 30 minutes off the mask. There was no pain at the end of this time. The pressure was increased to 100° as a pain-provocative test. Since the increased pressure did not result in pain this time, the decompression was restarted from 108°, spending 40 minutes at each 2° step.

At 38 DONALDSON reported very slight pain in the right knee and occasional twitching of the left hip. The symptoms disappeared during the course of two 30 minute periods breathing 50% helium, 50% oxygen. Subsequently mild vague right knee pain recurred with each depth change, and disappeared during the 40 minute stop. At each stop he spent 20 minutes breathing chamber atmosphere and 20 minutes breathing 50/50 HeO2 by mask and was not recompressed. (See 2nd treatment schedule).

From 30° to 12° he experienced no pain. At the end of the 12° stop he reported pain in the left leg below the knee. His three team mates were locked into the igloo portion of the chamber complex to finish their decompression on the original schedule of 25 minutes/2 foot stop. A fresh tender was locked in to join DONALDSON who then was put on 100% O2 and recompressed to 30°. The chamber atmosphere was switched to air. The recompression was slow because the pain shifted to the right knee and groin, and increased with the increased pressure. (See 3rd treatment schedule). One of the medical officers locked in at 30°, and a thorough physical examination was unremarkable. Thirty minutes after the pain was gone completely the decompression was continued as per the 3rd treatment schedule, and the surface was reached without further incident.

Those were no post-dive sequellae. Physical examination, routine laboratory values, and multiple x-rays of both knees were all normal.

DONALDSON's repeated susceptibility to decompression sickness in the same anatomical location during deep dives has location to this disqualification from the Man-in-the-Sea program. This does not necessarily mean, however, that he can not participate in standard Navy diving. The decompression schedules centinue to undergo evaluation at the Experimental Diving Unit.

C.VJ. RUBERTEIN

LT. IC. USIR

NOT REPRODUCIBLE

# 1st TREATLE: N SCHEDULE

100	DEPTH	INSPIRED GAS	TILE
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		Chamber	20 minutes

No pain - proceeded with 2 foot decompression stops, spending 20 minutes on 50/50 NeO2 and 20 minutes on Chambell gas at each stop.

#### 3rd TREATTHE SCHEDULE

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REPORT OF DECOMPRESSION SICKHESS AND ALL DIVING ACCIDENTS ORIGINAL - TO PUMED, WASHINGTON, D. C. COPY - TO FEP. DIVING UNIT, REVAL GUN FACTORY MAYMED-816 (REV. 2-56) THE AND ADDRESS OF REPORTING STATION U.S. HAVY EXPERIMENTAL DIVING UNIT 14 DEC 1966 MASHINGTON MANY YARD, WASHINGTON, D. C. 20390 I DENTIFICATION NUMBER 965 52 77 SFII2 (DV) STUBES, Joe Pete DIVING QUALIFICATIONS (Check one) AGE WEIGHT HEIGHT BUILD (Check one) MENDEN HEC-HEAVY DOESE MAST 1/6 U.S. 70 29 216 X YPS. RECORD OF ALL DIVES MADE DURING THE TWELVE HOURS PRECEDING THE ACCIDENT (If more than three dives were made, record additional under "RENARIS" on reverse.) FIRST DIVE SECOND DIVE THIRD DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE 150 000 081 27:31::15 TYPE OF EQUIPMENT TYPE OF EQUIPMENT TYPE OF EQUIPMENT CLOSEO CIRCUIT SCUBA OPEN CINCUIT SCUBA CLOSED CIRCUIT SCURA OPER CLOSED CIRCUIT SCUBA SHALLOW WATER MASK OTHER OPER CIRCUIT SCUBA .... DTHER SEE ADDITIDUIT TYPE OF WORK TYPE OF WORK TYPE OF WORK MILD MODERATE HEAVY MILO HORE HOHE MODERATE MEAVY 3000 MILD MODERATE HEAVY BREATHING MEDIUM BREATHING MEDIUM BREATHING MEDIUM WELIUM S OXYGER S DXYGER | DTHER (Specify) MELIUM S ORYGEN S OXYGEN OTHER (Specify) HELIUM & DEVGER & DEVGER AIR OTHER (Specify) A18 SEE ADDEIDUM SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM HELIUM-BAYGER GASOLINE BARRS COMPRESSOR MELIUM-ONYGEN GASOLINE BANKS COMPRESSON OTHER ALR BARES D.THE . ALD BARKS HELIUM-DRYGER GASOLINE COMPRESSOR DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE .DES.COMPRESSION SCHEDULE STANDARD SURFACE USING HE. DECOMPR. STANDARD SURFACE USING HE. DECOMPR. TABLE USEO TABLE USED TANDARD SURFACE USING HE. DECOMPR. TABLE USED DAYGE ALR DXYGER AIR DAYGEN SEE NDDE: DUI HIR. TIME REACHED SURFACE TIME REACHED SOTTOM RATE OF ASCENT RATE OF ASCENT TIME LEFT SURFACE RATE OF ASCENT TIME LEFT SURFACE TIME LEFT TIME REACHED BOTTOM TIME REACHED BOTTOM SEE ADDELIDUIL FI/MIN FT/HID FT/MIN If surface decoupression used, time from If surface decoupression used, time from If surface decompression used, time from last unter stop to 1st chamber stop. last water stop to 1st chamber stop last water stop to 1st cheaber stop. DEPTH WATER DEPTH WATER DEPTH WATER CHAMBER OF STOP OF STOP MINUTES DREATHING AT STOP MEDIUM MINUTES BREATHING AT STOP MEDIUM OF STOP MEDILY MINUTES BREATHING AT STOP MEDIUM (feet) (feet) 210 210 210 200. 190 200 200 JOIC. 190 190 180 **-180** 180 ADDE: DUI 7110\_ MEDEPT\_ 170 170 160 160 160 AST E VG\_\_\_ 150 APO. 150 150 140 140 140 1361 YEOMAI 130 130 120 120 120 110 110 110 <del>-1966</del> 15 DE 100 100 100 90 90 90 80 80 70 70 70 60 60 60 50 50 50 40 40 40 30 30 30 20 20 20 10 10 10

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					SIGNS AND SYMPTONS BEFORE TREATMENT	
		DATE	NSET	TIME	ANATOMICAL LOCATION	INTENSITY (MILD, MOD., SEVERE)
OCALIZED PAIN	29	NOI	190	G	RIGHT KHEE	ILD-MODERAT
RASH						
MUSCULAR WEAKNESS						
NUMBNESS						
DIZZINESS						
VISUAL DISTURBANCES						
PARALYSIS						
UNCONSC LOUSNESS						
DYSPNEA (CHOKES)						
NAUSEA CR VOMITING						
MUSCULAR TWITCHING						
RESTLESSNESS						
CONVULSIONS						
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			TREATME	NT SCHEDUL	£			REC	URRENCE TRE	ATHENT SO	CHEDULE		
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120	53.4					120	53.4						
100	44.5					100	44.5						
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REMARKS: (Include sequence of events preceding the accident and subsequent result of treatment, noting any unusual contributing

C. J. RUDENSTEIN, LT, MC, USIR

SIGNATURE OF MEDICAL DEPARTMENT REPRESENTATIVE

# NOT REPRODUCIBLE

#### ADDE: DUM

STURES was one of 4 divers making a simulated saturation dive to 450°, with an excursion to 600° for 1 hour. The dive was carried out in a wet-dry chamber complex at the Experimental Diving Unit. The chamber atmosphere was maintained at 0.3 ATA of oxygen. Pressurization was accomplished and maintained with 100% helium. The planned decompression schedule consisted of a 25 minute stop at each 2 foot decrement.

At 124, after 67:25::00 of decompression, STUDDS reported moderate right knee pain. The pain had been present since about 150, and had not increased as the depth was decreased. Physical examination by Dr. Raymond (one of the four divers) was normal. He was treated with 80% helium/20% oxygen by mask for 20 minutes, and then with 32% HeO2 for two 30 minute periods. Intervening were 10 minute periods breathing chamber atmosphere. The pain was not relieved completely, so the chamber was pressurized to 165 where he was treated with five 30 minute periods breathing 22% HeO2. These periods were alternated with 30 minute periods breathing chamber atmosphere. Pain relief was complete after the 3rd period. Thirty minute after the last period on 32% HeO2 the decompression was re-started at the original rate.

At 20°, after 105:34::50 of decompression, STUBES again reported right knee pain. IMM (DV) REEDY was locked in, and he and STUBES were isolated from the 3 other divers who continued their ascent to the surface. STUBES and REEDY were recompressed slowly on air, with STUBES breathing 100% oxygen. Complete relief was obtained at 32°, but repressurization was continued to 60°. After 25 minutes on oxygen he reported right calf pain. There were no significant physical findings. He then spent 10 minutes on air, 20 minutes on 02, 10 minutes on air, and 20 minutes on 02. After another 10 minutes on air the ascent was restarted at 1 FPM with STUBES breathing 100% 02. The pain recurred at 40°. He was re-pressurized to 50° with slight relief. A blood pressure cuff was placed around the affected calf and inflated. At 80 nm.Hg. the pain was markedly decreased. At 100 nm.Hg. the pain increased again. The cuff was released, and the pain vanished, never to return again. The ascent was resumed at 25 min./2° decrement up to 30°, then 40 minutes/2° decrement to the surface. The post-dive physical examination was normal.

Impression - decompression sickness.

This developmental decompression schedule is being revised in hopes of avoiding further decompression problems.

C. J. RUDENSTEIN

LT, IC, USIR

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	DATE	TIME	ANATOMICAL LOCATION	(HILD, MOD., SEVERE)
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UNCONSCIOUSNESS				
DYSPNEA (CHOKES)				
NAUSEA OR VOMITING				
MUSCULAR TWITCHING				
RESTLESSNESS				
CONVULSIONS .				
ACOUSTIC AURA				
P: RESTHESIA				

REMARKS: lother signs and symptoms before, during and following treatment)

PT noted stiffness alight pain RT knee at 170 relieved on A HR STOP at 150, returned at 110, relieved at 100 (4 HR stop), slight Esensation returned at 25', increased in intensity to 77' where ist reported. no other signs or symptoms could be alighted at that time or at any other point in the mathemat.

# NOT REPRODUCIBLE

			TREATME	NT SCHEDU	LE			REC	URRENCE TRE	ATHENT S	CHEDULE
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	H OF			n only when	MBER treatment table 3 or 4 is ment tables are altered)		H OF				BER n treatment table 3 or 4 ss twent tables are altered)
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165	73.4					165	73.4				
140	62.3					140	62.3		•		
120	53.4					120	53.4				
100	44.5					100	44.5				
80	35.6					80	35.6			•	
60	26.7					60	26.7				
50	22.3					50	22.3				
40	17.8			•		40	17.8				
30-	13.4					30	13.4				
20	8.9					20	8.9				
10	4.5					10	4.5				
TO SU	RFACE					TO S	URFACE				

REMARKS: (Include sequence of events preceding the accident and subsequent result of treatment, noting any unusual contributing factors - Use continuation sheet of needed)

SEE ATTACHED SHEET

SIGNATURE OF MICOICAL DIPARTHER REPRESENTATIVE

Prior to this dive the patient, Houle gives a history of injury to the involved extremity, occurring in a motorcycle accident approximately one year ago, causing severe contusions and abrasions in the general area of the present symptoms. In addition, he has had two previous cases of the bends, both within the 1st three months while working with the ADS IV Project in England. These bends manifested the same symptoms as those in the present case.

The dive was a 600 foot saturation run, descent in 14:35 44 hours on the hottom during which the Mark VIII semi-closed scuba rigs were swimtested in the vetpot. No excursion was attempted.

Ascent because at a rate of 2 minutes a foot to 570 where the rate of ascent was channel to 15 minutes per foot. This rate was held constant except for stops of four hours duration at  $450^\circ$ ,  $390^\circ$ ,  $150^\circ$  and  $100^\circ$ . Constant .3ATM  $9_0$  +  $8_0$  was maintained.

In retrospect, according to his own log, the first signs had appeared at 170; with a mild pain in the right knee which cleared at the 150' stop. It returned at 110 but was better after the four hour hold at 100 and gone at 96'. At 95' the sensation returned, involving the right knee and hip, gradually increasing in intensity until, on prompting by follow diver it was reported at 77' after 140: 15:00 hours decompression. (All times will refer to log times, indicating in this case time after leaving bottom).

Treatment was begun according to the protocol devised for treatment of cases occuring in saturation dives:

#### (Latters refer to enclosed garph)

- A. 140:15 Pain in right knee and hip reported, no further signs or symptoms elicited.
- B. 140:47 During recompression toward depth of relief Houle placed on He-32%02 mix by mask.
  - 141:32 Off Mask
- C. 141:32 Depth of Relief'll5 feet. No pain, no loss of strength or sensation

NOT REPRODUCIB

- 142:03 On Mask He-32002
- 142:28 Or Mask He-40%02
- 142:37 Off Mask
- 142:58 On Mask (40%)
- 103:29 Off Mask
- D. 143:36 On Mask (40%). Began Ascent to 90 feet according to treatment protocol, at rate of 1fpm.
- E. 144:03 Reached 90' changed rate of ascent to 20 Min/ft.
  - 144:08 Off Mask
- F. 161:01 Houle reports onset of mild ache modial aspect of right knee and right anterior thigh, occurred after reaching 39'.

  Again no other signs or symptoms.
  - 161:09 On 60-40 mix by mask
  - 161:39 Off Mask
  - 161:43 Other divers separated, tender sent from surface to join Houle in chamber, chamber taken down one foot to make seal

on hatch.

. G.	161:51	Beran descent toward sixty feet at 1 fpm. No change in
		symptoms. Pain was almost completely relieved at 50'
н.	162.38	Further improvement on reaching sixty feet. Pegan cycles
		of twenty minutes 100% 02 by mask.
	162:58	Off Mask
	163:09	On Mask during this period all symptoms had cleared.

163:07 On Mask 6 163:07 Off Mask 163:37 On Mask

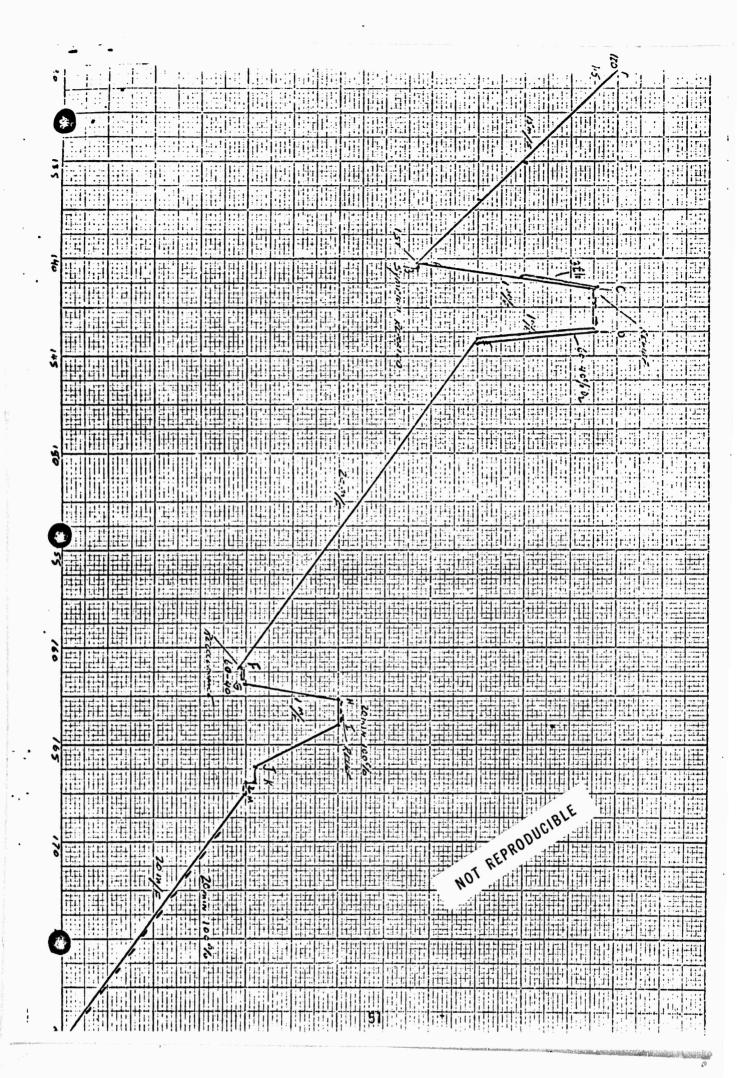
163:57 Off Mask
 163:59 Ascent to 50 feet at 1 fpm. Ho symptoms.

K. 166:50 Ascent to the surface at the rate of 20 minutes/foot, (actual travel 2ft at 1 fpm, then 33 minute holds). Each hour twenty minutes of 02 administered by mask.

N. 180:32 Surface

There were no residual symptoms, x-ray of the involved extremity was negative. The four other divers never manifested any signs or symptoms of decompression sickness.

NOT REPRODUCIBLE



REPORT OF DECOMPRESAION SICKNESS AND ALL DIVING ACCIDENTS

10

REPORTS SYMBOL: MED-6420-1

NAVHED 6420/1 (REV. 3-67) 5 N.0105-214-1650 ORIGINAL - BUMFD, WASHINGTON, D. C.
COPY - NAVY EXP. DIVING UNIT, WASHINGTON NAVY YARD, WASHINGTON, D. C.
COPY - NAVAL SUB. MED. CENTER, NAVAL SUB. BASE NEW LONDON, GROTGN, CONN. AND APPRIES OF REPORTING STATION

S. Navy Experimental Diving Unit, Wash. Navy Yard, Washington, D. C. 28 Mar 1268 GRADE/RATE | IDENTIFICATION NO. PO-CDI | RN P/JX389156 Bends CLARK, Dorck J. AGE WEIGHT HEIGHT BUILD (Check one) DIVING QUALIFICATIONS (Check one) R MED . HEAVY OBESE MAST E00 uws STU (OTHER) 33 170 70 X Z Royal Navy RECORD OF ALL DIVES MADE DURING THE TWELVE HOURS PRECEDING THE ACCIDENT (If more than three dives were made, record additional under "REMARKS" on reverse.) SECOND DIVE FIRST DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE TYPE OF DIVE BOTTOM TIME WET 600 Saturat1 n fect TYPE OF EQUIPMENT TYPE OF EQUIPMENT TYPE OF EQUIPMENT OTHER OTHER OPEN CLOSED CIRCUIT CIRCUIT SCUBA SCUBA OTHER DEEP DEEP SEA HEL IUM Cham TYPE OF WORK TYPE OF WORK TYPE OF WORK MILD MODERATE HEAVY HEAVY NONE MILD MODERATE NONE MODERATE BREATHING MEDIUM BREATHING MEDIUM BREATHING MEDIUM HELIUM & OXYGEN & DXYGEN DTHER (Specify) AIR HELIUM % DXYGEN % DXYGEN OTHER (Specify) AIR HELIUM % DXYGEN % OXYGEN DTHER (Specify) 92.4 Ho, 6.0 N, 1.6 O SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM AIR BANKS HELIUM.DXYGEN GASDLINE COMPRESSOR AIR BANKS HELIUM-OXYGEN GASOL!NE COMPRESSOR HELIUM-DXYGEN GASOLINE DTHER X DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE STANDARD STANDARO SURFACE USING HE. DECOMPR. TABLE USED SURFACE USING HE. DECOMPR. TABLE USED SURFACE USING HE. DECOMPR. TABLE USED DXYGEN P.P P.P. MIN. TIME REACHED SURFACE RATE OF ASCENT RATE OF ASCENT TO FIRST STOP TIME REACHED SURFACE TIME REACHED TIME LEF RATE OF ASCENT TIME LEFT TIME REACHED BOTTOM TIME REACHED BDTTOM REACHED 02:30 1542 14:07 1 fpm 30 Mar FT/MIN 20 Mar If surface decompression used, time from If surface decompression used, time from If surface decompression used, time from last water stop to 1st chamber stop. last water stop to 1st chamber last water stop to 1st chamber DEPTH DEPTH DEPTH \*ATER CHAMBER WATER CHAMBER WATER CHAMBER OF STO OF STOR OF STO MINUTES BREATHING AT STOP MEDIUM MINUTES BREATHING AT STOP MEDIUM (feet) (feet) (feet) 210 210 210 SER ATTACHED SHEET 200 200 200 190 190 190 180 180 180 170 170 170 100 160 160 150 150 150 140 140 740 130 130 130 120 120 120 110 110 110 100 100 100 90 90 90 80 80 80 70 70 70 60 60 60 50 50 50 40 40 40 30 30 30 20 20 20

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10

		0	NSET		T		INTENSITY				
		DATE	1436 1	TIME	1	ANATOMICAL LOCATION					
ALIZED PAIN	23	Mar	68	1 500	Loft	Inoa	Nod.				
RASH											
MUSCULAR WEAKNESS											
NUMBNESS											
DIZZINESS					<b></b>		<b>****</b>				
VISUAL DISTURBANCES											
PARALYSIS											
UNCONSCIOUSNESS											
DYSPNEA (CHOKES)							<i>99</i>				
NAUSEA OR VOMITING							<b>(</b>				
MUSCULAR IWITCHING											
RESTLUSSNESS							<i>&gt;&gt;&gt;&gt;</i>				
CONVULSIONS						•					
ACOUSTIC AURA					į.						
PARESTHESIA					,						

PEMARKS: (other signs and symptoms before, during and following treatment)

# No other signs or symptoms

_				TREATME	NT SCHEDUL	Ε	RECURRENCE TREATMENT SCHEDULE					
Á	LE	FT SURFA	CE	REI	.IEF	TIME REACHED BOTTOM	LEF	T SUR	FACE	REL	.IEF	TIME REACHED BOTTOM
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_	FEET	LBS	М	INUTES AT	STOP	BREATHING MEDIUM	FEET	LBS	М	INUTES AT S	тор	BREATHING MEDIUM
_	165	73.4					165	73.4	1			
_	140	62.3					140	62.3	3			
_	120	53.4					120	53.4	1			
_	100	44.5					100	44.5	5			
_	80	35.6					£,O	35.6	5			·
	60	26.7					60	26.7	7			
_	50	22.3				1	50	22.3	3			
_	40	17.8					40	17.8	3			
_	30	13.4					30	13.4				
_	20	8.9					20	8.9				
_	10	4.5					10	4.5	3			
	TO SI	JRFACE					TO SU	RFACE	:			

SIGNATURE OF MEDICAL OFFRETMENT PEPPESENTATIVE

HAVHED SH20/1 (SACK)

53

#### Decemprossion

Ascended from 600 to 570 at rate of 1 fpm, chamber 02 had been raised slightly prior to ascent. Hold constant ascent rate of 15 minutes per foot except for four hour stops at 460, 300, 150, 100 feet. Decompression was uneventful until 51 feet.

#### Bond

28 March

1500 At fiftyone, -two fest CLARK noted pain in the prepatellar area left knee, worse with exercise, no other symptoms

## Evaluation

History: no previous bends, rugby injurious to both legs 5-10 years previously. No other trouble during this dive, no trauma recently. Now at fifty feet has sensation in both kness.

Physical: vital signs normal, no resh, chest clear 50 foot stop to P and A. No crepitus in joints or tondons, no changes in the fundus. Norvous system intact, no parasthesias in the affected area. Pain relieved during exam.

#### Treatment

23 March

NOT REPRODUCIBLE 1615 Pain recurred at fifty foot stop, during peal, after short rest,

1633 put on 100% 02

1653 Off 02 Some improvement

1710 Worse in both knees

1711 On 100% O2 proparing to split complex

1731 Off Og (50 feet) Reedy sent down as tender Chamber pressurized 1747 Buch better at sixty feet, going on 60-40 mix

1750 Prin worse spreading to thigh procesurizing chamber

1820 Some improvement, giving trial of 60-40 mix at this depth

1840 Off mix, knee clear, thigh mild ache, encouraging hydration. Return depth according to protocol - 66.8 ft.

1858 On mix

1920 Off mix no rosidual symptoms

1949 On mix no residual symptoms

2000 Off mix no recidual symptoms

2030 Walking in chamber, no eyaptoms, rate of ascent switched to twenty minutes/foot (at 75 feet)

#### 29 March

0200 Holding for four hours at fifty feet. No change.

0700 Continuing ascent at 20 fpm. No change.

0815 Added 100% 02 for 40 minutes every 10 feet to regimen. No symptoms

#### 30 March

0150 CLARK on surface, no symptoms, no signs on physical.

# REPORT OF DECOMPRESSION SICKNESS AND ALL DIVING ACCIDENTS MAYHED 6420/1 (REV. 3-67) ORIGINAL - BIMMED, WASHINGTON, D. C. CODY - NAVY EXP. DIVING UNIT, WASHINGTON NAVY CAPY, MASHINGTON, D. C.

1500813 SYH301: MED-6420-1

N- 20429

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(over)

					SIGNS AND SYMPTONS BEFORE TREATMENT	
		C	INSE	ſ	ANATOMICAL LOCATION	INTENSITY
		DATE.		TIME	ANATOMICAL ECONTION	(Milia, NGS., SEVERE)
LOCALIZED PAIN	29	MAR	68	0750	left knee	mod.
RASH						
MUSCULAR WEAKNESS						
NUMBNESS						
DIZZINESS						
VISUAL DISTURBANCES						
PARALYSIS						
UNCONSCIOUSNESS					XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	
DYSPNEA (CHOKES)						
NAUSEA OR VOMITING						
MUSCULAR TWITCHING					1	
RESTLESSNESS						
CONVULSIONS						
ACOUSTIC AURA						
PARESTHESIA						

REMARKS: (other signs and symptoms before, during and following treatment)

#### SEE ATTACHED SHEET

			TREATME	NT SCHEDU	LE			REC	URRENCE TRI	ATMENT S	CHEDULE
LE	FT SURF	ACE	REL	IEF	TIME REACHED BOTTOM	LE	FT SURF	ACE	. REL	.IEF	TIME REACHED BOTTOM
DATE 29MAR	68 08		UNK	10°	see attached sheet	DATE	TIME		TIME	DEPTH	
see a sheet	ttach	ed	REACHED DATE 28 MAR	SURFACE VIME 1018	other	TIM	E ON BOT	MIN.	REACHED DATE	SURFACE	TREATMENT TABLE USED
	H OF	· (s	tops filled i used or when	CHAN in only when other trea	MBER n treatment table 3 or 4 is tment tables are altered)		TH OF TOP			n only whe	MBER m treatment table 3 or 4 is itment tables are altered)
FEET	LBS	A.	INUTES AT	STOP	BREATHING MEDIUM	FEET	LBS	М	INUTES AT	TOP	BREATHING MEDIUM
165	73.4					165	73.4				
140	62.3					140	62.3				
120	53.4	SEI	ATTACE	IED SH	EET	120	53.4				
100	44.5					100	44.5				
80	35.6					80	35.6				
60	26.7					60	26.7				
50	22.3					50	22.3				
40	17.8					40	17.8				
30	13.4			•		30	13.4				
20	8.9					20	8.9				
10	4.5					10	4.5				
TO SI	JRFACE					TO SL	RFACE				

REMARKS: (Include sequence of events preceding the accident and subsequent result of treatment, noting any unusual contributing factors - Use continuation sheet if needed)

SEE ATTACHED SHEET

DE SUMMITT, COR, MC, USX

SIGNATURE OF MEDICAL DEPARTMENT REPRESENTATIVE

MANNED 6420/1 (BACK)

- 24422

Ascent from 600 to 570 feet at 1 FPM, Chamber 02 had been raised slightly prior to ascent. Hold constant rate of ascent of 15 MPF except for 4 hour stops at 450, 300, 150, 100 and 50 feet.

20 minutes after surfacing the patient began complaining of left knee pain. He was placed on 100% O2 by mask and recompressed over a ten minute period to 30 feet. The patient complained of marked increase in pain coincident with compression and it was decided to return to a shallower depth. Considerable improvement was noted upon reaching 10 feet, so the patient was held for one hour of O2 breathing at that depth. He was then surfaced, still breathing O2, at a rate of 5 minutes per foot. He surfaced asymptomatic and experienced no further difficulty.

#### TREATMENT SCHEDULE

Left surface	0808	
Reach 30'	0819 ( E	reathing 100%
Leave 30'	0823	xygen by mask
Reach 10'	0828	
Leave 10'	0928	
Reach Surface	1018	

# REPORT OF DECOMPRESSION SICKNESS AND ALL DIVING ACCIDENTS

NAVHED 6420/1 (REV. 3-67)

10

REPORTS SYMBOL: MED-6420-1

ORIGINAL - BUMED, WASHINGTON, D. C. COPY - NAVY EXP. DIVING USIN, ASSURINGTON NAVY EXP. DIVING USIN, ASSURINGTON NAVY EXP. ASSURINGTON, S. C. COPY - NAVAL SUB. WID. CIVILE, NAVAL SUB. ASSURING USIN, NAVAL SUB. ASSURING USIN, NAVAL SUB. S'N.0105.214.1650 NAME AND ADDRESS OF REPORTING STATION Navy Experimental Diving Unit, Bldg. 214, WNY, Washington, D.C. 25 APR 1968 IDENTIFICATION NO. LCDR UNKNOWN Decompression Sickness **GIESS** AGE WEIGHT HEIGHT BUILD (Check one) DIVING QUALIFICATIONS (Check one) IENER MLD. HEAVY OBCSE 31 UNK UNK Diving Officer RECORD OF ALL DIVES MADE DURING THE TWELVE HOURS PRECIDING THE ACCIDENT
(11 more than three dives were made, record additional under "REMARKS" on reverse.) FIRST DIVE SECOND DIVE TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME TYPE OF DIVE DEPTH OF DIVE BOTTOM TIME URY 600 feet 4192 TYPE OF EQUIPMENT TYPE OF LOUIPMENT TYPL OF LOUISMENT CLOSED CIRCUIT SCUBA DPFN CIRCUIT SCUBA CLOSED CIRCUIT SCUBA GPIN GIRCUIT SCURA CLEGGED CLEGGET SCURA OTHER DEEP SEA HELIUM DFEF SEA HELIUM DIFP SFA HELIUM OPEN CIRCUIT SCUBA DEFP OTHER CHAMBER TYPE OF WORK TYPE OF WORK TYPE OF WORK NONE MILD MODERATE HEAVY NONE MILC MODE BATE HEAVY NONE MILD MODERATE HEAVY BREATHING MEDIUM BREATHING MEDIUM BREATHING MEDIUM HELIUM & DAYGEN & DAYGEN OTHER (Specify) AIR HELIUM & OXYGEN & DXYGEN DTHER (Specify) AIR HELIUM & OXYGEN & TOXYGEN GTHER (Specify) 92.4% He, 6% N2 1.6% 02 SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM SOURCE OF BREATHING MEDIUM AIR BANKS | HELIUM-OXYGEN | CASOLINE AIR BANKS HELIUM-OXYGEN GASOLINE HEL IUM-DXYGEN GASOLINE DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE DECOMPRESSION SCHEDULE STANDARD SURFACE USING HE. DECOMPR. STANDARD SURFACE USING HE. DECOMPR. - TABLE USED SURFACE USING HE. DECUMPR. TABLE USED TABLE USED AIR ONYGIN AIR OXYGEN AIR OXYGEN SATURATION TIME RATE OF ASCENT TO FIRST STOP TIME LEFT SURFACE TIME REACHED T TIME REACHED BOTTOM RATE OF ASCENT TIME REACHED TIME REACHED BOTTOM TO FIRST STOP SURFACE 15 APR 09:45 1 FT/MIN 25 APR 2214 If surface decompression used, time from last water stop to 1st chamber stop. If surface decompression used, time from If surface decompression used, time from last water stop to 1st chamber stop. DEPTH DEPTH DEPTH WATER CHAMBER WATER CHAMBER WATER CHAVBER OF STUP OF STOR MINUTES PREATHING MINUTES BREATHING MINUTES BREATHING AT STOP MEDILM MINUTES BREATHING feet) (feet) 210 210 200 200 200 190 190 190 SEE ATTACHED SHEET 180 180 180 170 170 170 160 160 160 150 150 150 140 140 140 130 130 130 120 120 120 110 110 110 100 100 100 90 90 90 80 80 70 70 70 60 60 60 50 50 50 40 40 40 30 30 30 20 20 20

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			SIGNS AND SYMPTONS BEFORE TREATMENT	
	ONSET		ANATOMICAL LOCATION	INTERSITY
	DATE	TIME	ANATOMICAL LOCATION	(MILG. WO., SEVERE)
LOCALIZED PAIN	24 APR 68	2305	Right thigh	Mild
RASH				
MUSCULAR WEAKNESS			•	
NUMBNESS				
DIZZINESS				
VISUAL DISTURBANCES				
PARALYSIS				
UNCONSCIOUSNESS				
DYSPNEA (CHOKES)				
NAUSEA OR VOMITING				
MUSCULAR TWITCHING				
RESTLESSNESS				
CONVULSIONS				
ACOUSTIC AURA				
PARESTHESIA				

## SEE ATTACHED SHEET

TREATMENT SCHEDULE							RECURRENCE TREATMENT SCHEDULE						
LEFT SURFACE			RELIEF		TIME REACHED BOTTOM		LEFT SURFACE		RELIEF		TIME REACHED BOTTOM		
DATE	TIME		0510	DEPTH			DATE	TIME		TIME	DEPTH		
NA NA		<u> </u>	25 APR	25'	NA NA		<b> </b>				<u> </u>		
TIME	ON BOT	TOM	REACHED SURFACE			TABLE USED	TIME ON BOTTOM			REACHED SURFACE		TREATMENT T	ABLE USED
· NA			DATE TIME 02 breat		athing				DATE	TIME			
		MIN.	25 APR	1130	during	decompre:	sion M		MIN.				
DEPTH OF STOP		CHAMB (Stops filled in only when used or when other treatm			treatment to	ble 3 or 4 is re altered)	DEPTH OF STOP			CHAMBER  tops filled in only when treatment table 3 or 4 is used or when other treatment tables are altered)			
FEET	LBS	MINUTES AT STOP		BREATHI	NG MEDIUM	FEET LOS		М	MINUTES AT STOP		BREATHING MEDIUM		
165	73.4					165	73.4						
140	62.3						140	62.3					
120	53.4		SEE ATT	ACHED S	HEET		120	53.4					
100	44.5						100	44.5					
80	35.6						80	35.6					
60	26.7						60	26.7					
50	22.3			•			50	22.3					
40	17.8						40	17.8					
30	13.4			+ 11			30	13.4					
20	8.9						20	8.9					
10	4.5						10	4.5					
TO SURFACE			TO SL	RFACE									

REMARKS: (Include sequence of events preceding the accident and subsequent result of treatment, noting any unusual contributing factors - Use continuation sheet if needed)

SEE ATTACHED SHEET

SIGNATURE OF MEDICAL DEPARTMENT REPRESENTATIVE

MANNED 6420/1 (BACK)

Ascent from 600 to 570 feet a 1 FPM. Used constant rate of ascent thereafter of 15 MPF except for 4 hour stops at 450, 300, 150, 100 and 50 feet.

Shortly after leaving the 50 foot stop the subject reported mild pain lower right thigh. It has been intermittent over the previous 3 days of decompression. Since the symptoms were mild, it was decided to treat with periods of oxygen by mask and continue decompression.

2305	24 APR	Symptoms reported.
2305-2325	11	100% oxygen, significant relief.
0400-0420	25 APR	100% oxygen
0425-0445	11	100% oxygen
0450-0510	"	100% oxygen - complete relief
0900-0920	11	100% oxygen
0925-0945	11	100% oxygen
0950-1010	11	100% oxygen
1130	"	Surface